LARGE IMAGES

In a Direct-Viewing Type Cathode-Ray Tube for Television

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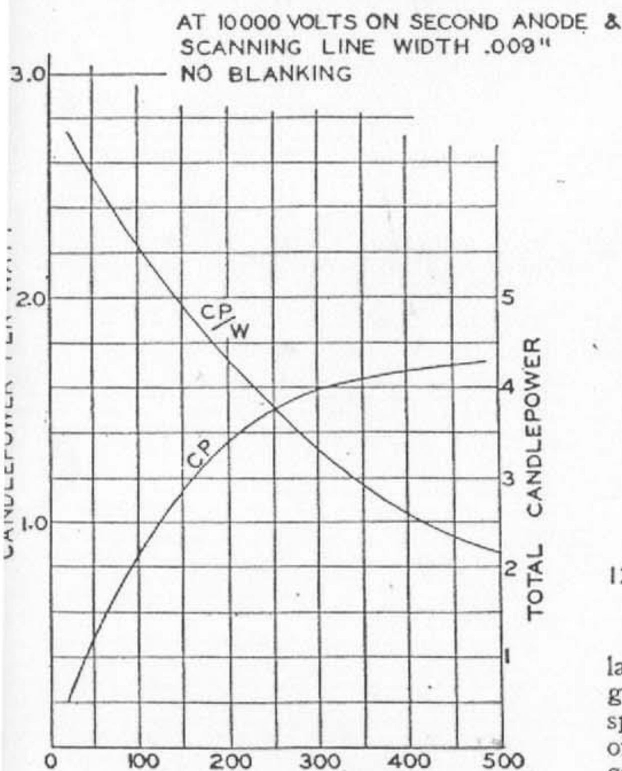
SUMMARY—*A new device for obtaining large ight television images of high contrast and gh definition has been developed at the ımden Laboratories of the RCA Manufactur- g Company. It is a direct-viewing cathode-ray be 4½ feet long and 31 inches in diameter. is of the continuously evacuated type and ves a picture 18 by 24 inches in size. The ıper describes the design and construction of e new tube, the reasons for the development, e difficulties which were overcome, and the sults obtained.*

EVER since high-definition television pictures were first demonstrated, newspaper writers and laymen have commented on the small size of the picture. Seemingly it has been of little interest that the size of the picture has had little to do with the amount of information communicated. In early work on high-definition systems a 9-inch diameter cathode-ray tube was used to produce a picture approximately 6 by 8 inches. Most of the present direct-viewing cathode-ray tubes are 12 inches in diameter and produce pictures approximately 7½ by 10 inches. Even so,



CURRENT SATURATION OF YELLOW WILLEMITE IN 3-INCH KINESCOPE

FIG. 1
Current-saturation of a willemite screen.

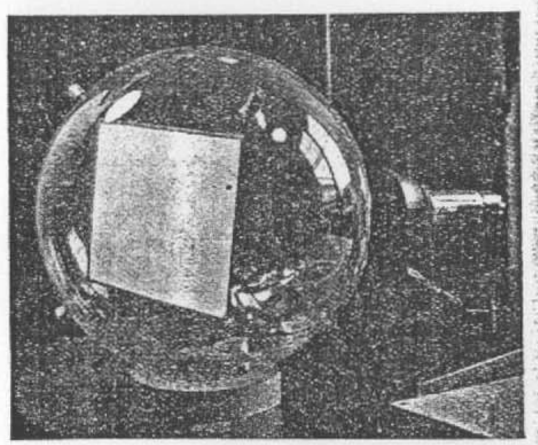


FIG. 2
12-inch direct-viewing television cathode-ray tube for large light output at high contrast.

larger pictures are wanted. Consequently, a great amount of effort and money have been spent here and abroad in the quest for methods of producing large television images having adequate brightness, contrast and definition.

Many solutions to the problem of obtaining large television images have been proposed and several methods have been extensively explored. Interesting demonstrations have been given here and abroad. Frequent mentions of the projection cathode-ray tube method and also of the

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current technical news.

The purpose of this paper is to describe another method of obtaining large television pictures, namely, the method of large direct-viewing cathode-ray tube development. This tube was built with the primary purpose of studying television pictures of large size (18 by 24 inches) under conditions where brightness, contrast and definition were adequate and where the method of reproduction did not limit the performance of the system.

LIGHT BASED ON AREA

The most important consideration in favor of the large direct-viewing cathode-ray tube is that the total amount of light obtainable from a luminescent screen is directly proportional to the area of the screen. This point will be clarified further.

At present the most widely used luminescent materials for screens in cathode-ray tubes are: the zinc orthosilicate (willemite) and the zinc sulphide. Both materials exhibit the property known as "current saturation." A current-saturation curve of a yellow willemite screen, bombarded by 10,000-volt electrons in a developmental projection tube, is shown in Fig. 1.

Measurements show that under the conditions of normal television scanning this saturation is a function of the area of the scanning spot and not of the total scanned area. But the area of the scanning spot is necessarily a function of the total area, if the detail of the picture is to be preserved; i.e., it cannot be larger than a certain fraction of the total area scanned. In actual practice, since the luminous spot is round, a certain overlap of the scanning lines is permissible. As a limit, after which a serious loss of detail takes place, 50 per cent overlap may be taken. The present tentative standard calls for 441 lines per frame, about 10 per cent of which are blanked out during vertical synchronizing time. The observed picture, therefore, consists of 400 horizontal lines. Allowing 50 per cent overlap this calls for the line width of one-half of one per cent of the height of the reproduced picture as the limiting maximum line width.

It may be deduced from the curves of Figure 1 that at 10,000 volts the maximum useful brightness of this particular type of luminescent screen is 0.7 candlepower per square inch or 100 candles per square foot. The maximum useful beam current (while it is on) is 58 μa per square inch, but when the average power over a period of one complete white frame is considered, it is only 0.80 of the product of volts and amperes (max.).

The factor of 0.80 is introduced because in actual operation the electron beam scans a given picture area for only 80 per cent of the time since 20 per cent of the time it is extinguished for the line and frame returns or fly-backs.

DISPUTE ON LIGHT NEED

As to the minimum required brightness of the screen, opinions vary greatly. As a yardstick, the brightness of a motion-picture screen is often used. A committee of the Society of Motion-Picture Engineers concludes that the if eye fatigue is to be completely avoided.* The recommendation, however, is that 0.86 to 1.65 candles per square foot be adopted as a temporary standard. There is very good reason to believe that a television picture should have more light than that. The author's experience indicates that at no time has he seen a television image that was too bright in a normally lighted room. With the tube shown in Fig. 2, with 1.1 ma in the beam at 10,000 volts on the second anode, high-lights of 40 candles per square foot were obtained. The picture was bright and permitted demonstrations in a brightly illuminated room, but no observer pronounced the picture as being too bright. In a dark room such a picture is definitely too bright.

The reason for low screen brightness being satisfactory for motion-picture theatres is that there is practically no stray light and the size of the image is very large. The theatre hall is devoted to the showing of pictures and everybody there is looking at the picture. The television receiver is placed in a room which is used for other purposes. It may be the living room of a residence, a hotel lobby, or a restaurant. To be of maximum usefulness, a television receiver should not interfere with any other functions of the room. The willemite screen by itself, at 10,000 volts, is capable of giving a surface brightness as high as 100 candles per square foot or 314 foot-lamberts or apparent foot-candles. For a screen 18 by 24 inches it would require 25 ma at 10,000 volts. For the previously mentioned figure of 40 cp per square foot, only 6 ma at 10,000 volts are required. The lower the current density of the luminous spot, the higher is the screen efficiency. At 2 ma and 10,000 volts a directly bombarded luminescent willemite screen of the type described will have brilliancy of 14.6 cp per square foot or 46-foot lamberts which is nine times the upper brightness limit of the tentative SMPE standard.

TUBE COMPLETED

During the first quarter of the present year the construction of a direct-viewing TCR tube with screen 18 inches by 24 inches was completed at the Camden Laboratory of the RCA Manufacturing Company, Inc. The tube is of the demountable, continuously-evacuated type and has a metal envelope with a Pyrex sight glass. Fig. 3 (front cover) shows a side view. The envelope is made of good grade steel ¼-inch thick with arc-welded seams and flanges.

It has the shape of a cone, and is 4.5 feet in length. The outside diameter of the larger flange is 31 inches. A three-stage oil-diffusion pump is directly connected to the tube through a special outlet. For fore-vacuum, a mechanical vacuum pump is connected to the diffusion pump by means of a length of rubber hose. The glass cover is convex outward, 31 inches in diameter and 2 inches thick. This thickness is re-

(Continued on next page)

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d because the total atmospheric pressure on lass is approximately 5½ tons. A special ine was constructed in the laboratory for ing and polishing both surfaces of the . The technique used was that of grinding ope lenses. A layout of the grinding ma- is shown in Fig. 4.

r vacuum-tight joints between the glass and l as well as between metal flanges, pure rubber gaskets proved very satisfactory. performance of the tube is quite satisfactory 1 vacuum of the order of 10^{-6} mm Hg is ned. Normally such a vacuum is reached 48 hours of operation. The vacuum meas-

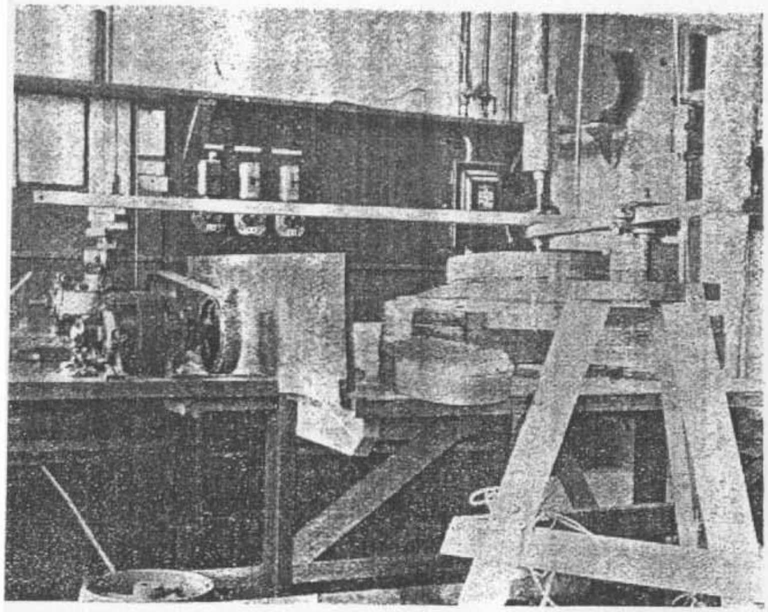


FIG. 4

hine for grinding and polishing glass covers for 31-inch TCR tube.

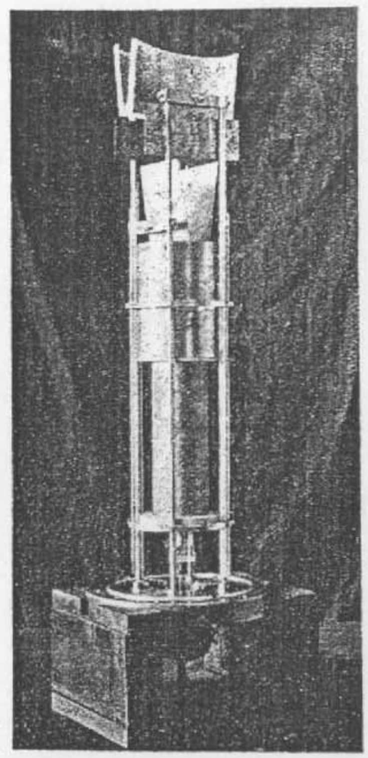
nents are made by means of thermocouple ionization gauges attached to the sleeve con- ing the vessel and the diffusion pump.

he tube was designed for 10,000 volts on second anode. For safety reasons, instead perating the metal envelope at 10,000 volts tive, it is grounded and the cathode is raised he same voltage, but negative. This ar- gement greatly facilitates the construction of electron gun. The electron gun used in this is shown in Fig. 5. It gave beam cur- s as high as 8 ma at 10,000 volts with cor- onding brilliancy of the high-lights. How- , the best overall performance was obtained a gun giving 2 ma in a narrow beam with igible defocusing and with — 150 volts cut- grid voltage.

he design of the power supply and video lifier for the demountable tube offered many culties. The cathodes in the last stages he video amplifier had to be operated at ıs 10,000 volts and, of course, had to be city-coupled somewhere along the chain to low-voltage stages. The two coupling con- ers during the operation are charged to 00 volts and at the same time are required meters and controls on the last stages of amplifier had to be insulated for 10,000 volts. A view of the portable outfit containing the video amplifier, synchronizing and deflecting circuits, and high and low-voltage supply, is shown on the right-hand side of Fig. 3 (front cover).

NO BULGING

It will be noted from the photograph that the sides of the image are straight and there is no apparent bulging of the image. The reason for this effect is that the 2-inch thick glass disc



At right is electron gun for the big tube.

FIG. 5

is used only as vacuum cover or a sight glass while the luminescent material is deposited on a flat glass sheet ¾-mm thick, which is fastened to the walls of the tube. The flat appearance of this type of luminiscent screen is not its only advantage. The fact that it is flat greatly improves the overall contrast of the reproduced picture. On a concave screen, illuminated parts throw light directly on the blacks of the image, thereby reducing the contrast. The fact that the screen glass is thin improves the contract in details by reducing the well-known "halation" or "the spurious ring" effect.

The author acknowledges the valuable help and cooperation of his associates in carrying out the developments described, especially Dr. D. W. Epstein and Mr. K. R. Wendt, both of the General Research Division of the RCA Manufacturing Company, Inc., at Camden, N. J. The 31-inch glass disc was ground and polished with the assistance of Mr. D. D. Landis of the Photophone Division of the same company.